Tackling the Volatility Paradox: Spillover Persistence and Systemic Risk

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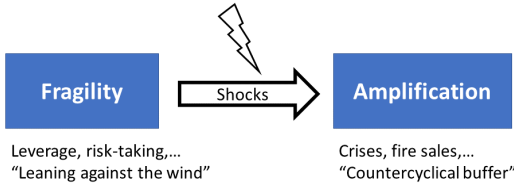
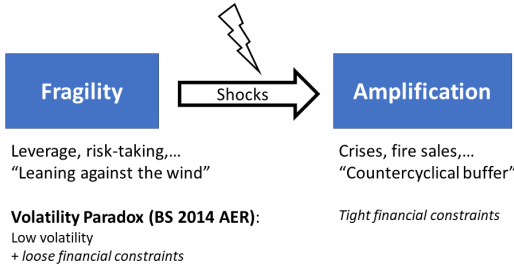
April 2021

Systemic Risk



Traditional risk measures $\approx$ contemporaneous volatility $\times$ correlation (e.g., ΔCoVaR, MES)

Systemic Risk

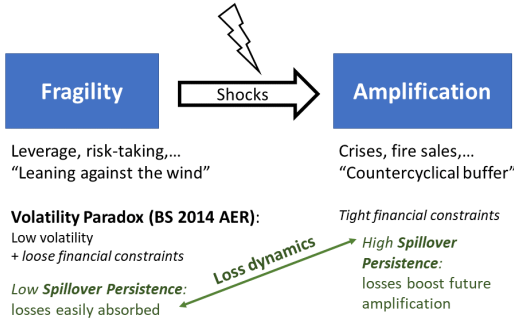


Traditional risk measures $\approx$ contemporaneous volatility $\times$ correlation (e.g., ΔCoVaR, MES)

"*Volatility paradox rules out using contemp. risk measures*" (Brunnermeier and Oehmke (2013))

$\Rightarrow$ Empirical measures 💔 Theory

Systemic Risk



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This paper: **Disentangle normal times vs. fragility vs. amplification**

Crises: fragility vs amplification

Decline before crises (fragility) & **increase during** crises (amplification)

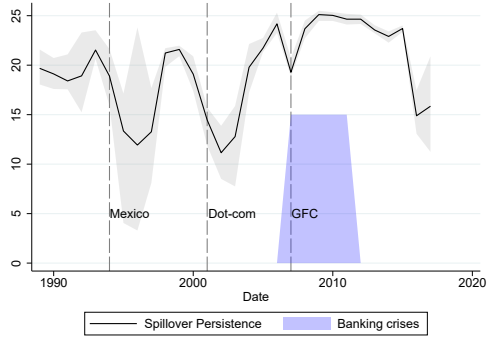


Figure: Spillover Persistence in the US: Average + 25/75th percentile.

This paper

- Spillover Persistence: "for how long does the system's risk increase after JPM has losses?"
- >700 financial firms from 25 countries, 1985-2017

Results:

(I) Spillover Persistence ↓ when fragility ↑
- before banking crises and stock market bubbles burst
- w/ & w/o controlling for ΔCoVaR, credit, GDP, investment,...

(II) Why? Financial constraints channel
- Leverage and risk-taking ↑ when Spillover Persistence ↓

(III) Spillover Persistence ↑ when amplification ↑
- during crises
- for insurers exposed to hurricane Katrina (↔ fire sales)

Contribution

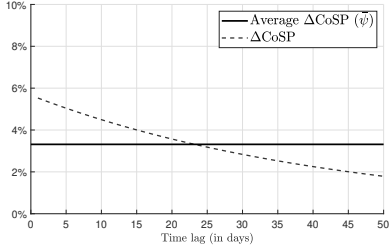
- Novel dimension: loss dynamics.
  - **Empirics**: framework to explore fragility (financial constraints) at firm-level
  - **Theory**: empirical support for modern macro-finance theory, particularly volatility paradox in Brunnermeier and Sannikov (2014) and Adrian and Boyarchenko (2012)
  - **Policy**: predict crises, adjust to fragility vs. amplification times (countercyclical regulation)
- Extend systemic risk measure literature
  - ΔCoVaR (Adrian and Brunnermeier (2016)) + Granger causality (Billio et al (2012))
- Consistent with financial constraints being
  - looser at the run-up of crises and asset price bubbles (e.g., Schularick and Taylor (2012), Jordá et al. (2015), Brunnermeier et al. (2020))
  - tighter during fire sales (e.g., Ellul et al. (2011, 2015), Girardi et al. (2020))

ΔCoSP Methodology

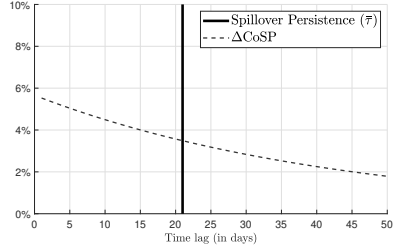
Probability of large losses of the system <u>after</u> JP Morgan experienced large losses

$$\Delta\text{CoSP}(\tau) = \underbrace{\mathbb{P}\left(\text{loss}^{\text{system}}_{t+\tau} \geq VaR^{\text{system}}_{q} \mid \text{loss}^{\text{firm}}_{t} \geq VaR^{\text{firm}}_{q}\right)}_{\text{after firm's losses}} - \underbrace{\mathbb{P}\left(\text{loss}^{\text{system}}_{t+\tau} \geq VaR^{\text{system}}_{q}\right)}_{\text{on average}}$$

Average ΔCoSP: total risk



Spillover Persistence ≈ duration



Data and estimation

- Loss: Daily stock return loss, 1985-2018,
  all financial firms in Europe, North America, Asia, Japan, Australia
- System = value-weighted index of financial firms in same region

After an average firm's losses, the probability of large losses in the system is

- 4ppt larger (Average ΔCoSP),
- at a time horizon of $\approx$ 1 month (Spillover Persistence)

	N	Mean	Median	SD	Min	Max
Average ΔCoSP ($\bar{\psi}$, in ppt)	10,977	3.60	2.83	2.92	0.02	9.59
Spillover Persistence ($\bar{\tau}$, in days)	10,977	19.04	20.99	7.14	2.17	27.34

Firm-year observations, 1989-2017.

cor(Spillover Persistence, ΔCoVaR)$< 10\%$ $\Rightarrow$ Novel dimension

Overview

Banking crises

Hypothesis: Spillover Persistence↓ before banking crises ↔ Fragility↑

Test: Predict crisis in year $t+1$ in firm i's country c, controlling for

- level of systemic risk ($\bar{\psi}_{i,t}$)
- macroeconomic characteristics (ΔGDP, Δcredit, TED, inflation, interest rates,...)
- firm and year fixed effects

$$\text{Crisis}_{i,t+1} = \alpha \cdot \underbrace{\bar{\tau}_{i,t}}_{\text{Spillover Persistence}} + \beta \cdot \bar{\psi}_{i,t} + \underbrace{\gamma \cdot \mathbf{M}_{c,t} + u_i + v_t}_{\text{Macro characteristics \& Firm \& Year FE}} + \varepsilon_{i,t+1}.$$

» Descriptives

Declines in Spillover Persistence precede crises

Dependent variable:	(1)	(2)	(3)	(4)	(5)	(6)
Sample:			Crisis_{t+1} Baseline			Output loss $\text{Crisis}_{t+1} = 1$
Spillover Persistence	-0.005***		-0.002***	-0.002***	-0.002***	-0.009**
	(0.001)		(0.010)	(0.008)	(0.008)	(0.016)
Average ΔCoSP	0.048***		0.026***	0.026***	0.028***	0.054***
	(0.000)		(0.000)	(0.000)	(0.000)	(0.002)
ΔCoVaR		0.040***		-0.023**		
		(0.001)		(0.041)		
ΔCoSP(0)					-0.001	
					(0.158)	
Macro characteristics	No	No	Yes	Yes	Yes	Yes
Firm characteristics	No	No	No	Yes	Yes	Yes
Firm & Year FE	No	No	Yes	Yes	Yes	No
No. of firms	738	738	738	738	738	395
No. of obs.	8,000	8,000	8,000	8,000	8,000	1,382
Adj. R^2 within	0.113	0.029	0.291	0.293	0.292	0.663

t=last ΔCoSP estimation year. 26 countries, 1989-2017. Macro characteristics are inflation, ΔGDP, Δinvestment, log(interest rate), Δcredit, Δshort-term yield, Δterm spread, TED spread, Δcredit spread, average equity return and volatility. Standard errors clustered at firm and year-country levels. ***, **, * significance at 1%, 5% and 10% levels, p-values in parentheses.

Spillover Persistence↓ ↔ future crises↑ ↔ fragility↑

⏩ Country level

Declines in Spillover Persistence precede crises...

... particularly when financial conditions are loose & firms have strong balance sheets
$\leftrightarrow$ financial constraints channel

Dependent variable:	(1)	(2)	(3)	(4)	(5)
			Crisis_{t+1}		
Sample:	US	Baseline		Ban & Bro	
Spillover Persistence $\times$ Tight financial conditions	0.010***				0.011***
	(0.000)				(0.001)
Spillover Persistence $\times$ Investment growth		-0.004***			
		(0.005)			
Spillover Persistence $\times$ Liquidity ratio			-0.002*	-0.002*	-0.001
			(0.050)	(0.069)	(0.129)
Spillover Persistence $\times$ Impaired loans			0.002**	0.002**	0.001
			(0.024)	(0.011)	(0.129)
Spillover Persistence $\times$ Intangible assets			0.001**	0.001**	0.001*
			(0.017)	(0.028)	(0.052)
Bank characteristics	No	No	Yes	Yes	Yes
NFCI	Yes	No	No	No	No
Spillover Persistence & Average ΔCoSP	Yes	Yes	Yes	Yes	Yes
ΔCoVaR	No	No	No	Yes	No
Firm FE & Firm characteristics	Yes	Yes	Yes	Yes	Yes
Year FE & Macro characteristics	No	Yes	Yes	Yes	Yes
No. of obs.	2,831	8,000	1,426	1,426	1,426
Adj. R^2 within	0.354	0.300	0.386	0.389	0.411

Additional interactions omitted. Standard errors clustered at firm and year-country levels. ***, **, * significance at 1%, 5% and 10% levels, p-values in parentheses.

Overview

Asset price bubbles

Emergence of bubbles $\leftrightarrow$ build-up of fragility (Brunnermeier and Oehmke (2013))
Hypothesis: bubble booms $\leftrightarrow$ low Spillover Persistence

Test: Regress firm i's Spillover Persistence at year t on stock market bubble indicator in country c:

$$\bar{\tau}_{i,t} = \underbrace{\alpha \cdot I_{c,t}^{Boom} + \beta \cdot I_{c,t}^{Bust}}_{\text{Bubble indicators}} + \underbrace{\gamma \cdot L_{c,t}^{Boom/bust}}_{\text{Boom \& bust length}} + \underbrace{\xi \cdot M_{c,t}}_{\text{Macro controls}} + \underbrace{u_i}_{\text{Firm FE}} + \varepsilon_{i,t}.$$

Descriptives

Booms ↔ low Spillover Persistence

Dependent variable:	(1)	(2)	(3)	(4)	(5)
	Spillover Persistence$_t$				Spillover Persistence$_{t+4}$
Sample:	Baseline			Ban & Bro	All
Boom	-3.671***	-3.573**	-1.897**	-1.751*	-1.983**
	(0.001)	(0.014)	(0.018)	(0.070)	(0.031)
Bust	-0.097		0.384	-0.281	-1.432
	(0.949)		(0.660)	(0.916)	(0.129)
Bubble		-0.097			
		(0.949)			
Macro characteristics	Yes	Yes	Yes	Yes	Yes
Additional macro & firm characteristics	No	No	Yes	Yes	Yes
Bank characteristics	No	No	No	Yes	No
Boom & bust length	Yes	Yes	Yes	Yes	No
Year FE & ΔCoVaR	No	No	Yes	Yes	No
Firm FE	Yes	Yes	Yes	Yes	Yes
Scaled coefficients					
Boom	-.52	-.51	-.27	-.27	-.29
No. of firms	693	693	693	153	640
No. of obs.	7,592	7,592	7,592	1,295	7,043
Adj. R^2 within	0.115	0.115	0.029	0.040	0.096

Macro controls: inflation, Δcredit, ΔGDP, Δinvestment, log(interest rate), banking crises; additional: Δ3M yield, Δterm, TED, and Δcredit spread, equity market return and volatility; firm controls: size, leverage, and market-to-book; bank controls: liquidity ratio, and demand deposits, time deposits, loans, impaired loans, and intangible assets / total assets. Standard errors clustered at firm and country-year level. ***, **, * significance at 1%, 5% and 10% levels, p-values in parentheses.

Bubble booms ↔ low Spillover Persistence

Booms ↔ low Spillover Persistence...

... particularly when financial conditions are loose & firms have strong balance sheet ↔ financial constraints channel

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:			Spillover Persistence			
Sample:	US	Baseline		Ban & Bro		
Boom × NFCI	23.677***					
	(0.000)					
Boom × Investment growth		-2.091***				
		(0.000)				
Boom × Leverage			7.424***	4.656**		
			(0.000)	(0.021)		
Boom × Liquidity Ratio			-15.804***	-12.715**		
			(0.000)	(0.012)		
Boom × Impaired Loans			8.169***	6.113***		
			(0.000)	(0.004)		
Boom × Burst Distance × NFCI					4.148**	
					(0.029)	
Boom × Burst Distance × Liquidity Ratio					-4.139*	-4.498*
					(0.063)	(0.072)
Boom × Burst Distance × Impaired Loans					3.324***	3.279*
					(0.006)	(0.074)
Firm characteristics	No	Yes	Yes	Yes	Yes	Yes
Bank characteristics	No	No	Yes	Yes	Yes	Yes
NFCI	Yes	No	No	No	Yes	No
Boom & Bust & length	Yes	Yes	Yes	Yes	Yes	Yes
Macro characteristics & Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes	No	Yes
No. of obs.	2,714	7,592	1,295	1,295	1,119	1,119
Adj. R^2 within	0.283	0.038	0.435	0.074	0.524	0.075

Additional interactions omitted. Standard errors clustered at firm and country-year level. ***, **, * significance at 1%, 5% and 10% levels, p-values in parentheses.

Overview

Leverage and risk-taking

Financial constraints channel: link between Spillover Persistence and fragility.

Spillover Persistence↓ ↔ leverage and derivatives exposure↑

Dependent variable:	(1)	(2)	(3)	(4)	(5)	(6)
	Leverage$_{t+1}$				CDS$_{t+1}$	
Sample:	All			Ban & Bro		
Spillover Persistence	-0.048*	-0.100**	-0.132**	-0.120**	-0.007*	-0.003
	(0.070)	(0.044)	(0.021)	(0.034)	(0.083)	(0.537)
Spillover Persistence × Impaired loans				-0.229***		-0.020***
				(0.000)		(0.008)
Spillover Persistence × Intangible assets				-0.017		-0.012**
				(0.547)		(0.043)
Macro & Firm characteristics & Average ΔCoSP	Yes	Yes	Yes	Yes	Yes	Yes
Bank characteristics	No	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	Yes	Yes	Yes	Yes
Standardized coefficients						
Spillover Persistence	-.022	-.047	-.063	-.057	-.047	-.019
No. of obs.	9,710	1,607	1,607	1,607	668	668
Adj. R^2 within	0.080	0.140	0.073	0.112	0.068	0.162

Additional interactions omitted. ***, **, * significance at 1%, 5% and 10% levels, p-values in parentheses.

Overview

Fire sale amplification

Hypothesis: fire sales $\Rightarrow$ Spillover Persistence $\uparrow$

Quasi-natural experiment:
Hurricane Katrina $\Rightarrow$ 41 billion USD P&C claims ($> 2\times$insurance premiums)

- forced exposed insurers to sell assets
- *Exposed*: US P&C insurers in top quartile of premiums written in Alabama, Louisiana and Mississippi
- daily CoSP for broker-dealer system (18m backward-looking estimation window)

Descriptives

Fire sales and Spillover Persistence

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable:	Spillover Persistence						ΔCoVaR
Sample:	US insurers	All insurers			Placebo	All insurers	
System:	Broker-dealer			NonFin		Broker-dealer	
Exposed × post-Katrina	0.811***	1.213***	0.811**	-0.041		0.977*	0.279
	(0.000)	(0.001)	(0.027)	(0.930)		(0.055)	(0.425)
Exposed × post-Placebo					0.036		
					(0.959)		
ΔCoVaR						0.016	
						(0.773)	
Insurer FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Day FE	Yes	Yes	No	No	No	No	No
Country × Day FE	No	No	Yes	Yes	Yes	Yes	Yes
Scaled coefficients							
Exposed × post-Katrina	.19	.32	.21	-.011		.25	.22
No. of firms	27	71	71	69	69	71	71
No. of obs.	820	2,095	2,095	1,941	2,156	523	523
Adj. R^2 within	0.018	0.017	0.008	-0.001	-0.001	0.005	-0.001

Exposed= 1 for US P&C insurers in top quartile of premiums in Alabama, Louisiana and Mississippi. Placebo: August 1, 2005. Standard errors (1) unclustered, (2-7) clustered at firm level. ***, **, * indicate significance at the 1%, 5% and 10% levels respectively.

Larger increase in Spillover Persistence for exposed insurers relative to unexposed

Robustness

Possible concerns:

- Rolling window estimation:
  cluster at firm-level, include lagged dependent variable, control for bubble length
- Persistence explained by equity market illiquidity?
  No (Amihud, turnover)
- Persistence explained by omitted shocks that hit system twice/persistently?
  No (system acf, pre-whitening)
- Persistence explained by omitted shocks that hit first firm but not system, then system?
  Cannot control for $\Rightarrow \Delta CoSP \neq$ *causal identification of loss spillovers*

Conclusions

- Spillover Persistence: firm's losses today relate to system's losses in 1 month, on average
- Swing & hit dynamics:
  - Spillover Persistence $\downarrow \leftrightarrow$ fragility $\uparrow$
    - run-up of crises and bubbles
    - banks take more risks (higher leverage and derivatives exposure)
  - Spillover Persistence $\uparrow \leftrightarrow$ amplification $\uparrow$
    - during crises
    - fire sales after Katrina
  - Channel: financial constraints

$\Rightarrow$ Empirical support for modern dynamic macro-finance models

$\Rightarrow$ Tackle volatility paradox: focus on loss dynamics

$\Rightarrow$ Theory ❤️ Empirical measures

Thank you!

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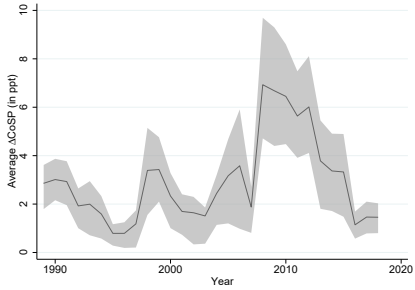
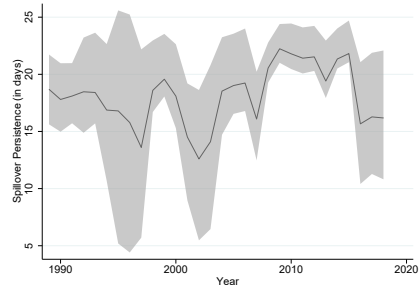
Backup & Appendix

CoSP measures over time



(a) Average ΔCoSP



(b) Spillover Persistence

back

Descriptive statistics: Macroeconomic characteristics

Table: Macroeconomic characteristics: descriptive statistics.
After merging data for $\bar{\tau}$ and ΔCoVaR.

Country-year level	N	Mean	Median	SD	Min	Max
Inflation (in ppt)	544	2.21	1.99	1.87	-0.05	5.40
Credit growth (in ppt)	544	2.29	1.87	5.43	-5.33	10.38
GDP growth (in ppt)	544	4.66	4.56	3.40	-0.66	9.56
Investment growth (in ppt)	544	-0.24	0.28	5.32	-9.21	6.89
log(interest rate)	544	1.04	1.39	1.01	-1.26	1.99
Crisis	544	0.13	0.00	0.34	0.00	1.00
Region-year level	**N**	**Mean**	**Median**	**SD**	**Min**	**Max**
3M yield change (in bps)	74	-0.53	-0.10	2.27	-5.02	2.50
3M yield change (in bps)	74	-0.53	-0.10	2.27	-5.02	2.50
Term spread change (in bps)	74	0.11	-0.30	2.60	-2.88	2.93
TED spread (in bps)	74	32.31	26.74	31.59	0.05	93.71
Credit spread change (in bps)	74	-0.03	-0.09	1.86	-3.17	2.88
Market return (in ppt)	74	0.15	0.20	0.38	-0.53	0.61
Equity volatility (in ppt)	74	1.02	0.93	0.44	0.49	2.05

back

Spillover Persistence and banking crises: country level

Dependent variable:	(1)	(2)	(3) Crisis$_{t+1}$	(4)	(5)	(6) Output loss$_{t+1}$
Spillover Persistence	-0.017*	-0.024**	-0.024**	-0.025***	-0.021**	-0.681**
	(0.078)	(0.013)	(0.013)	(0.010)	(0.012)	(0.030)
Average ΔCoSP	0.059**	0.061**	0.061**	0.055	0.097***	1.946**
	(0.013)	(0.025)	(0.025)	(0.216)	(0.001)	(0.010)
ΔCoVaR			0.021			
			(0.831)			
ΔCoSP(0)				0.003		
				(0.775)		
Macro controls	No	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	No	No	Yes	No
(1-5) Scaled & (6) standardized coefficients						
Spillover Persistence	-.07	-.1	-.1	-.1	-.09	-.27
Average ΔCoSP	.16	.17	.17	.15	.27	.52
ΔCoVaR			.03			
ΔCoSP(0)				.04		
No. of countries	12	12	12	12	12	12
No. of obs.	140	140	140	140	140	140
Adj. R^2	0.099	0.280	0.274	0.275	0.657	0.236
Adj. R^2 within	0.099	0.310	0.305	0.306	0.316	0.236

Country-year-level averages weighted by firms' total assets; countries included once there are at least 15 firms present. Macro characteristics are inflation, ΔGDP, Δinvestment, log(interest rate), Δcredit, Δshort-term yield, Δterm spread, TED spread, Δcredit spread, average equity return and volatility. Standard errors clustered at year and country levels. ***, **, * indicate significance at the 1%, 5% and 10% levels respectively. P-values are in parentheses.

back

Dynamics during booms

Dependent variable:	(1)	(2)	(3)	(4)
Sample:	Within Bubble	Spillover Persistence Baseline		Ban & Bro
Boom × Burst Distance	-2.253***	-1.645***	-1.665***	-3.328***
	(0.005)	(0.007)	(0.005)	(0.001)
Macro characteristics	Yes	Yes	Yes	Yes
Additional macro characteristics	Yes	Yes	Yes	Yes
Firm characteristics	No	Yes	Yes	Yes
Bank characteristics	No	No	No	Yes
Boom & bust	Yes	Yes	Yes	Yes
Boom & bust-years	No	No	Yes	Yes
Boom & bust length	Yes	Yes	Yes	Yes
ΔCoVaR	No	No	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
No. of firms	250	596	596	135
No. of obs.	1,163	6,270	6,270	1,119
Adj. R^2	0.369	0.296	0.318	0.560
Adj. R^2 within	0.182	0.144	0.171	0.513

Macro controls: lagged inflation, Δcredit, ΔGDP, Δinvestment, log(interest rate), banking crises, Δ3M yield, Δ term spread, TED spread, Δ credit spread, equity market return and volatility; firm controls: size, leverage, and market-to-book; bank controls: liquidity ratio, and demand deposits, time deposits, loans, impaired loans, and intangible assets relative to total assets. Standard errors clustered at firm and country-year level. ***, **, * significance at 1%, 5% and 10% levels, p-values in parentheses.

⇒ Persistence particularly low during bubble start, larger around burst.

back